HABITAT AND VIABILITY MODELING BASED ON MAXENT, ZONATION, AND HEXSIM

The habitat and viability modeling methods are sound and innovative. The planning team has used a coherent series of analysis tools to make best use of available data to inform planning. Two aspects deserve particular praise:

1) Use of newly available information (e.g., GNN vegetation layer, Forsman et al. (in press) NSO metaanalysis monograph, database of NSO locations, new delineation of modeling regions).

2) Use of 'state-of-the-art' modeling tools (Maxent, Zonation, Hexsim) which are connected in a logical process in which output from initial stages informs successively more complex modeling tools. Due to the effort made by the modeling team to solicit relevant data from the literature and experts, the structure of the Hexsim scenario is highly complex and potentially more informative than simpler models used in past NSO conservation planning. However, the modeling methodology can and should be strengthened in key aspects in order to better inform recovery planning:

<u>Conduct broader peer review of Maxent models by field biologists</u>

The planning team used a defensible modeling process for development of the Maxent models, and solicited expert input to develop the suite of candidate models. However, there has been some criticism from field biologists as to model accuracy, especially in the California modeling regions where topographic and other variables dominate over variables related to forest age and structure. Since the Maxent results form the foundation for the rest of the modeling process, it would be useful to review Maxent results for California with researchers from that area, e.g., those associated with the CA demographic studies.

<u>Analyze threats from barred owl (BDOW) in a different context than habitat-based threats to viability, and frame Hexsim results as informing decisions rather than predicting outcomes</u>

While it is appropriate that a subset of the Hexsim model scenarios include effects of BDOW on NSO demographic rates, it should be recognized that the means by which the effect of BDOW on NSO was modeled is qualitatively different that how habitat effects were considered. The BDOW effect as modeled is effectively non-spatial, in that there is no data on either 1) BDOW distribution (below the scale of the modeling region), or linkage between BDOW abundance and habitat quality. There is new data (Dugger unpubl.) suggesting that habitat and BDOW threat factors may interact, in that extinction rates of NSO territories were higher on territories with BDOW detections, and this effect was stronger as the amount of habitat decreased. However, given the scarce available data, it is defensible to model

BDOW as a non-spatial effect. But this imposes limitations on interpretation of the Hexsim model results. In a sense, the BDOW effect parameterization simply lead Hexsim to simulate an exponentially declining population (i.e., it lowers survival rates in all habitats below the level necessary for population persistence). In contrast, the relationship between habitat and demography is modeled in a spatial manner, based on the extensive published data on habitat/distribution and habitat/demography relationships (although this too is challenging as described below).

The contrast between model parameterization for the two main threat factors (habitat loss and BDOW) implies the need for two types of Hexsim simulations:

1) Equilibrium scenarios comparing alternate habitat configurations

These would compare equilibrium carrying capacity under different reserve scenarios. Typically one needs to run simulations for ~100-150 years before the population equilibrates. So simulations would be run for e.g., 250 years, and results (population size and distribution) would be reported as averaged over e.g., years 150-250. If environmental stochasticity is added (as suggested below), it is necessary to run multiple simulations (typically 50-100) per scenario, as the variance may be as important as mean population size. To make this more computationally feasible (as Hexsim by default runs replicates one after each other), the user can make multiple copies of each scenario and run them in parallel on one computer. Since these scenarios focus on equilibrium behavior, the results would not be interpreted as predicting a population trajectory over time. Most studies have shown that SEPM are better used to rank alternative managment options than to predict e.g., extinction time or transient dynamics, due to these latter metrics having high uncertainty to alternate parameterizations. These equilibrium scenarios may have to use ‘optimistic’ demographic parameter sets to be most informative. Populations in most parts of the NSO range show declines (Forsman et al. in press "populations on four study areas declined 40–60% during the study, and populations on three study areas declined 20–30%") yet many aspects of SEPM simulations that respond to stochastic factors (e.g., distinguishing effects of size and spacing of habitat clusters) are swamped when such rapid deterministic declines are modeled, so equilibrium scenarios such as described above are more informative.

2) Because the BDOW factor as parameterized predicts eventual extinction of many populations (in part due to its lack of a link to habitat condition), equilibrium scenarios containing a BDOW effect are uninformative (equilibrium is at zero). BDOW simulations thus offer a different type of decision support than habitat-based equilibrium scenarios. Simulations analyzing the effect of BDOW should instead focus on comparing the transient dynamics (population trajectory) with and without BDOW, but with an awareness of the limitations of the model. It is important to describe these BDOW-related results

separately and to document the relative confidence (i.e., strengths and weaknesses) of the habitat and BDOW parameterization.

It is incorrect to interpret population trajectories output from Hexsim as predicting population status/size. There is little information on the current NSO population size outside of demographic study areas (DSA), and less on population size in the past. Transient dynamics in SEPM are often dominated by artifacts of the initial conditions in the model and, barring substantial effort at model calibration and sensitivity analysis, results should not be interpreted as predicting population size at a particular point in time.

<u>Incorporate environmental stochasticity into Hexsim scenarios</u>

Many of the more subtle effects of contrasts between alternate conservations strategies e.g., effects of reserve size and spacing on viability, may only become evident when environmental stochasticity is incorporated into the scenario. This is one of the strengths of using a complex model such as Hexsim, and should be taken advantage of to avoid the typically overly optimistic results obtained when environmental stochasticity is not considered. Environmental stochasticity may be especially important in declining populations, as Forsman et al. (in press) state: "variation [in survival] often corresponded closely to the variation in λ and was most noticeable in study areas where populations were declining the most, especially those in Washington."

<u>Address potential effects of climate change, in either a qualitative or quantitative manner</u>.

Recent studies have addressed potential effects of climate change on NSO (e.g., Carroll 2010). Additionally, because the Maxent NSO models include climate variables that are also available as projections under future climate scenarios, it is feasible to calculate projected habitat value under future climates using the Maxent models. Despite the many inherent uncertainties in these projections, they are informative and preferable to not addressing this potential threat factor.

<u>Conduct sensitivity analyses on assumptions concerning effect of habitat on demography</u>

Currently, the Hexsim scenarios model habitat value (as derived from Maxent) as influencing NSO survival but not reproduction. This is a defensible interpretation of the literature, but other parameter structures are nearly as plausible. The modeling team explained (pers. comm.) that the decision to model the effects of habitat on survival was based on the fact that populations are most sensitive to changes in adult survival rates, and substantial published literature (Franklin et al. 2000, Olson et al.

2004, Dugger et al. 2005) documents these effects. All of these modeling efforts found a significant effect of the amount of old forest around nest sites on survival rates. However, although the recent metaanalysis (Forsman et al. in press) represents the most important recent addition to the above studies, the team was unable to directly use habitat-demography relationships from this study to parameterize Hexsim. Although a habitat effect was significant and positive in the metaanalysis's fecundity models for Oregon, the habitat covariate was not significant in the best models for Washington as all of the confidence intervals overlapped zero, even though habitat was in the best models for these study areas. There was no comparable habitat data for California in the meta-analysis, so no results or conclusions were made for that portion of the owl's range. Consequently, the effects of habitat amount on fecundity were mixed and not very conclusive from the meta-analysis, which provided a considerable challenge in how to model such effects in HexSim. If one based the Hexsim parameterization directly on the meta-analysis results alone, they would suggest a habitat effect on fecundity in Oregon, but no effect on survival. The modeling team's approach was defensible, in that they used the metaanalysis to document the plausible range of demographic values, but also considered evidence from previous studies of a habitat effect on demography. Thus the range of survival values from the meta-analysis was used to represent the "potential" effects of the amount of habitat on survival. However, there is enough uncertainty in the above process, that alternate plausible parameterizations should be explored as part of the sensitivity analysis. A comparison of Hexsim scenarios with a range of parameter sets (e.g., 1) equilibrium vs. declining populations, and 2) habitat effects on survival only, fecundity only, and on both parameters), could provide general insights that can better inform planning that can a single parameter structure.

Explore alternative scaling of demography to habitat in HEXSIM

Current Hexsim scenarios are structured with three resource classes (low, moderate, and high), with the breakpoints set to 1/3 and 2/3 of an individual's target resource. It would be helpful as a sensitivity analysis to increase the number of resource classes (to e.g., 10) and see if this affects results. The demographic values assigned to the resource classes could be a straightforward interpolation from existing parameters for the 3 classes.

Consider potential role of lower-quality habitat

The team used Zonation settings that prioritized clumped habitat over fragmented habitat. This is generally appropriate, but, when combined with the fact that the lowest 30% of Zonation priority levels are not mapped, has the effect of excluding consideration of lower quality habitat. The underlying issue is what if any role does marginal-suitability habitat play in recovery. Such fragmented and/or marginal habitat is seen in much of the northern Oregon coast and southeast Washington. Although of lower quality, some portion of this type of habitat may need to be prioritized in recovery planning to accomplish population restoration goals or to enhance connectivity. Planners should consider how habitat restoration can best build on existing remnant habitat to restore subpopulation viability where necessary.

<u>Develop alternate habitat and landscape change scenarios</u>

A difficult question, discussed at the recovery plan workshop, is what assumptions should be made concerning future habitat trajectories in reserve vs. non-reserve areas. LandTrendr assessment of habitat change in the past decade doesn't reveal a strong contrast between change on reserved vs. non-reserved federal lands. But unless assumptions are made that habitat in reserves will strongly differ from that in non-reserved areas, the Hexsim model will not predict contrasting NSO viability under alternate reserve scenarios. It is not feasible to used detailed models (e.g., stand-level growth and succession models) to predict habitat change on a regional scale. Similarly, no attempt is made in the plan to link alternate fire and fuels management strategies to NSO habitat in the Hexsim simulations. Given these uncertainties, several alternate habitat change assumptions should be compared as part of a sensitivity analysis.

<u>Reference multi-species context of NSO conservation planning</u>

The Northwest Forest Plan was a pioneering example of multi-species planning that recognized that land managers can no longer afford to create single-species recovery plans that ignore the conservation requirements of other species of concern. As several peer reviewers commented, one of the major shortcomings of the 2008 NSO recovery plan was that it sought to turn back the clock on this effort and ignored the multi-species context of NSO recovery. The 2010 plan should correct this error. The plan should acknowledge that the system of LSR was created to conserve multiple species, and thus there are benefits to building on the LSR network rather than delineating an entirely novel system of reserves based on a new NSO model. Secondly, the plan should compare alternate NSO-based reserve scenarios with data on priority areas for other old-growth associated species to determine which alternatives best capture habitat for multiple species.